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Effect of ground-cover management on predatory mites (Acari: Phytoseiidae) in a Mediterranean vineyard

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Summary

Most predatory mites belong to the family Phytoseiidae (Acari). Throughout the world, phytoseiids are involved in the biological control of phytophagous mites in vineyards. Conservative strategies, including cover-vegetation management, are essential to achieve environmentally friendly viticulture. The abundance and diversity of phytoseiid mites in the grapevine canopy and the vegetal ground cover of a Mediterranean vineyard were surveyed by weekly samplings, from early May until the end of September for two years (2016 and 2017). Three types of soil management without herbicide application were analysed and referred to as "Tillage", "Spontaneous Cover", and "Flower-driven Cover" treatments. Six phytoseiid species were collected on the grapevine canopy, with *Typhlodromus pyri* being the dominant species (99.5 %). Five phytoseiid species were recorded in the ground cover, with *Typhlodromus* and *Neoseiulus* as the major genera. The Flower-driven Cover treatment showed the highest abundance of phytoseiids in the grapevine canopy. However, both species richness and abundance of phytoseiid mites on the ground-cover vegetation were highest in the Spontaneous Cover treatment. These observations suggest that improving vegetation cover would promote both the abundance and diversity of phytoseiid mites in vineyards because the greater supply of pollen would enhance their survival. Therefore, the use of cover crops in vineyards represents a means of improving vineyard ecosystems by conservative biological control.

Key words: agroecology; conservative biological control; cover crop; tillage; population dynamics; *Typhlodromus*.

Introduction

By focusing primarily on wine production, traditional methods of viticulture may endanger Mediterranean environments in countries where viticulture plays an important role. Spain is the country with the greatest area of vineyards in the world (OIV 2018) and, here, vineyards are usually managed through intensive practices, such as tillage and use of broad-spectrum pesticides. These methods can lead to soil erosion, pollution of natural resources, loss of biodiversity, reduction of natural enemies and development of resistance (Novara *et al*. 2013, Allan *et al*. 2015). Thus, the European Union (EU) has established agricultural policies to counter these problems; for example, the 2014-2020 CAP reform proposes reduced use of herbicides and employment of cover crops, and Directive 2009/128/EC on sustainable use of pesticides promotes the use of integrated pest management (IPM) programmes that lead to environmentally friendly viticulture.

Biological control (BC) is used to control arthropod pests, reduce toxic residues and preserve beneficial fauna in agroecosystems (Altieri 1999). The conservation of natural enemies of crop pests, which are present on crops and adjacent natural vegetation, is a major goal of IPM, and represents one of three major BC strategies (Jacas and Urbaneja 2010). Food-generalist arthropod predators constitute an important group of natural enemies because they are able to survive in the absence of their main prey (Landis *et al*. 2000, McMurtry *et al*. 2013). The Phytoseiidae (Acari) are the main group of predatory mites that live on the plants and include many species employed worldwide in the control of phytophagous mites (McMurtry 1982). Most phytoseiids feed on mite pests, including eriophyids, tarsonemids and tetranychids, and also small insects such as aleyrodids, psocids, scale crawlers and thrips. They may also consume fungal spores and substances of animal (e.g. honeydew produced by homopterans) and of vegetal (e.g. pollen and nectar) origin (McMurtry and Croft 1997). Their ability to feed on a variety of food resources, abundance, short generation time, wide distribution and ability to survive and reproduce on very low densities of prey make them good candidates for key biocontrol agents (Prischmann *et al*. 2006).

Worldwide, there are more than 2,400 species of phytoseiids, among which the most interesting and common species reported in European vineyards are *Typhlodromus pyri* Scheuten and *Kampimodromus aberrans* (Oudemans) (Duso *et al*. 2012, Demite *et al*. 2018, Tixier 2018). *T. pyri* is an important agent for biological control of potential phytophagous pests in European vineyards, including tetranychid mites (*Panonychus ulmi* (Koch), *Tetranychus urticae* Koch and *Eotetranychus carpini* (Oudemans)) and

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eriophyids (*Calepitrimerus vitis* (Nalepa) and *Colomerus vitis* (Pagenstecher)) that significantly deteriorate grape quality and yield. In addition, *T. pyri* can feed on grape powdery mildew (Pozzebon and Duso 2008) and is relatively tolerant to some pesticides (Marshall and Lester 2001, Duso *et al*. 2012).

Another potentially useful conservative strategy is the management of vegetation cover to promote biological control for sustainable viticulture (Thomson and Hoffmann 2009, Letorneau *et al*. 2011, Ratnadass *et al*. 2012, Daane *et al*. 2018, Garcia *et al*. 2018). Cover crops constitute a reservoir for phytoseiid mites by providing shelter and alternative food sources, especially pollen and nectar, in vineyards (Landis *et al*. 2000, Barbar *et al*. 2006, Aguilar-Fenollosa *et al*. 2011, Burgio *et al*. 2016). Furthermore, the presence of ground-cover vegetation can enhance phytoseiid performance by modifying the microclimate within crops, for example, by lowering temperature and elevating humidity, which are essential for egg survival (Tixier 2018). In addition, cover crops offer several other advantages including erosion reduction, improved soil properties and provision of key ecosystem services (Gago *et al.* 2007, Kazakou *et al.* 2016, Garcia *et al*. 2018). With respect to the latter, Soliveres *et al.* (2016) showed that a high multitrophic richness (including plant species richness) had stronger positive effect than richness in any individual trophic group on ecosystem services. Moreover, Sommaggio *et al.* (2018) reported that cover crops seem not to positively affect the vineyard pests. The composition of plant cover is a key factor that varies according to the goal pursued (Domínguez Gento *et al.* 2002). For example, the biology and development of predatory mites are greatly affected by plant features, especially domatia densities, leaf hairiness, extrafloral nectaries, and pollen production (Karban *et al.* 1995, Kreiter *et al*. 2002, Bresch *et al*. 2019, Gontijo 2019).

This paper aims to investigate the impact of different ground-cover management strategies (bare soil, spontaneous wild cover, and sown cover of a flowering mixture) on the abundance and diversity of phytoseiid mites on vine leaves and on inter-row vegetation in a Mediterranean vineyard. Our hypothesis was that by reducing crop intensification and providing suitable habitat and food requirements, we will achieve an increase in abundance and diversity of predatory mites. We also assessed the vegetation cover community to select the most profitable species to use as the cover crop, and the population dynamics of phytoseiid mites during the growing season when the biological control of mite pests is crucial.

Material and Methods

Study site: The study was conducted in a rain-fed vineyard within the Rioja appellation, Northern Spain. The vineyard, located in Logroño (42°26'N, 2°30'W), was planted in 1995 with the 'Tempranillo' variety of *Vitis vinifera* (clone RJ-26 grafted onto 110-R rootstock). Vine rows were east-west oriented with the plantation distance being 1.15 m between vines and 2.90 m between rows. The soil texture was mainly loam and sandy loam with low organic matter (< 1 %). Fig. 1 presents maximum temperature (°C) and relative humidity (%) data recorded by SIAR (Agroclimatic Information Service in La Rioja) in the two sampling years (2016-2017) at Logroño (La Rioja).

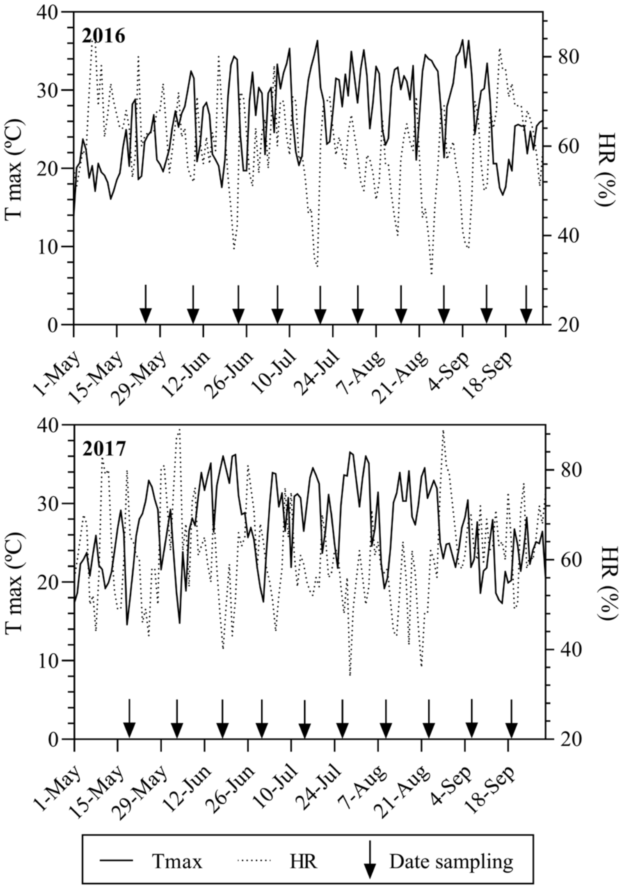

Fig. 1: Climatic parameters (maximum temperature and relative humidity) and sampling dates.

Experimental design: Three soil management techniques were analysed for two years (2016 and 2017): (i) 'Tillage', (ii) 'Spontaneous Cover', and (iii) 'Flower-driven Cover', using a completely randomized design with three plots per treatment. Each plot comprised 360 vines and 1,200 m^2. In the tillage treatment, a common management technique of under-vine bare soil was practised; in the Spontaneous Cover treatment, naturally occurring vegetation was managed through mowing once per year in June. The abundance, coverage and richness of weeds were estimated, and species identified, in mid-May using three quadrats of 1 m^2 that were randomly positioned in each plot. The Flower-driven Cover treatment was sown in the first week of March with 'Deco Vignes Anuelles' (Nova Flore, Champigné, France) (20 kg·ha^{-1}) consisting of a mixture of *Calendula officinalis* (Compositae), *Centaurea cyanus* (Asteraceae), *Cosmos bipinnatus* (Asteraceae), *Dahlia* sp. (Asteraceae), *Eschscholzia californica* (Papaveraceae) and *Lepidium* sp. (Brassicaceae), which bloom throughout the vegetative cycle of the vine.

Conservative Biological Control (CBC) strategies were carried out, including no herbicide use under vine plants and mating disruption for *Lobesia botrana* Den & Schiff (Lepidoptera: Tortricidae) control. Acaricides and

Table 1

Pesticide treatments applied to pest and disease control

Active ingredients	Date	Dose·ha^{-1}
Sulfur powder	28 May 2016	10 kg·ha^{-1}
Myclobutanil 12.5% p/v + (Folpet 40% + Metalaxil 10%)	3 June 2016	300 cc·ha^{-1} + 1.5 L·ha^{-1}
(Folpet 37.5% + Iprovalicarb 6%) + (Fluopyram 20% + Tebuconazol 20%)	24 June 2016	2 kg·ha^{-1} + 350 cc·ha^{-1}
Sulfur powder	30 June 2016	25 kg·ha^{-1}
(Dimetomorf 12% + Piraclostrobin 6.7%) + Spirodiclofen 24%	16 July 2016	1.25 kg·ha^{-1} + 200 cc·ha^{-1}
Quinoxifen 25% p/v + (Cimoxanilo 3% + Copper 22.5%)	2 August 2016	300 cc·ha^{-1} + 3.5 L·ha^{-1}
(Folpet 37.5% + Iprovalicarb 6%) + (Fluopyram 20% + Tebuconazol 20%)	26 May 2017	1.5 kg·ha^{-1} + 300 cc·ha^{-1}
Sulfur powder	8 June 2017	20 kg·ha^{-1}
Dimetomorf 12% + Piraclostrobin 6.7%	20 June 2017	1.25 kg·ha^{-1}
Sulfur powder	30 June 2017	25 kg·ha^{-1}
(Cimoxanilo 3% + Copper 15% + Mancozeb 10% WP) + Ciflufenamid 3% + Difenoconazol 6% p/v + Abamectin 1.8% p/v	13 July 2017	3 kg·ha^{-1} + 0.6 L·ha^{-1} + 1 L·ha^{-1} + 0.6 L·ha^{-1}
Cimoxanilo 3% + Copper 15% + Mancozeb 10% WP + Quinoxifen 25% p/v.	2 August 2017	3 kg·ha^{-1} + 250 cc·ha^{-1}

fungicides were applied to control *Eotetranychus carpini* (Oudemans) (Acari: Tetranychidae), downy mildew *Plasmopara viticola* [(Berk. & M.A. Curtis) Berl & De Toni], and powdery mildew (Oidium) *Erysiphe necator* Schwein, as shown in Tab. 1. These compounds are often used in the Mediterranean vineyards.

Mite sampling: Sampling was carried out every two weeks between the beginning of May and the end of September (n = 10 sampling events each year) (Fig. 1). At each sampling, 50 leaves without petioles were randomly collected from the grapevine canopy, and 150 g of the ground-cover vegetation from the cover-crop treatments, from the middle of each plot. Leaves, one per vine, were taken from the middle part of the shoot. These samples were transported to the laboratory in a paper bag in a cool-box, for mite extraction. Berlese-Tullgren funnels were used for 4 d to remove phytoseiids and these were preserved in 70 % ethanol in 9:1 glycerine. Young and adult phytoseiid stages were separated and counted using a stereoscopic microscope. Adult phytoseiids were digested in lactic acid (70 %) and mounted on slides in Hoyer's medium. Slides were placed on a hotplate (40 °C) to facilitate drying. Phytoseiid mites collected in 2017 were identified to species level under a phase-contrast microscope.

Statistical analyses: Data were analysed separately for each year. Biodiversity values of the floral community, Shannon-Wiener (H´) and 'True diversity' (^{q}D), were calculated by using Past3 (Hammer *et al*. 2001). True diversity was analysed as the 'effective numbers of species' and 'Hill number' (^{0}D, ^{1}D and ^{2}D) (Hill 1973, Jost 2006) Rank-abundance curves and Venn diagrams at species level were calculated to analyse the assemblages of the functional phytoseiid community, within both the grapevine canopy and the ground-cover vegetation. The population dynamics of phytoseiid mites were also studied. Normal distribution and homoscedasticity of data were confirmed using Kolmogorov-Smirnov and Levene tests, respectively. One-way analysis of variance (ANOVA) was used to compare abundances of mites among treatments, followed by post-hoc Tukey tests (P < 0.05), to assess statistical differences. Abundances of mites among cover-crop treatments were compared using *t*-tests. SPSS for Windows (version 20, SPSS Inc., Chicago, Illinois) was used for statistical analysis. All the figures were prepared using GraphPad Prism for Windows (version 8.00, GraphPad Inc., La Jolla California, USA).

Results

Plant community: A total of 26 weed species belonging to 24 genera and 13 families were identified from the Spontaneous Cover vegetation during 2016 and 2017. The cover consisted primarily of annual dicotyledonous plants, dominated by Scrophulariaceae, Urticaceae, Poaceae and Caryophyllaceae (Tab. 2). The percentage of weed coverage was higher than 70 %. Biodiversity values of cover-crop vegetation were always higher in Spontaneous Cover than Flower-driven Cover (Tab. 3) showing nearly three times higher species richness (^{0}D) and two times higher true diversity (^{1}D). The slightly lower diversity and higher q in the Flower-driven Cover may be explained by the presence of common species.

Species richness of phytoseiid mites: Rank-abundance curves at species level illustrate a huge dominance of *T. pyri* (99.42 %) in the grapevine canopy (Fig. 2A). However, this trend was less marked in the ground-cover vegetation, where *T. pyri* (55.26 %) was present along with *Neoseiulus barkeri* Hughes (15.79 %), *T. recki* Wainstein (14.47 %) and *N. agrestis* (Karg) (11.84 %) (Fig. 2B). Spontaneous Cover showed the greatest species richness both in the grapevine canopy and the ground-cover vegetation (Fig. 3), and the highest interaction between species richness and ground-cover management in the grapevine canopy (Fig. 4). At canopy level, *T. pyri*,

Table 2

Relative abundance of spontaneous cover crop vegetation

Genus	Relative abundance (%) 2016	Relative abundance (%) 2017	VP*
Monocotyledonous			
Bromus	8.84	8.07	-
Hordeum	4.55	3.85	E**
Lolium	1.15	-	-
Poa	0.82	-	-
Dicotyledonous			
Veronica	24.13	35.96	E**; T*
Urtica	2.9	14.99	E****
Stellaria	12.87	0.22	-
Capsella	5.95	0.56	-
Papaver	6.27	-	-
Sonchus	6.05	0.65	E**; T*
Melilotus	4.21	-	-
Centaurea	2.87	-	-
Geranium	0.38	0.77	K**; T**
Fumaria	0.92	-	-
Senecio	0.82	-	-
Medicago	-	0.77	T*
Rumex	0.57	-	E**
Helminthotheca	0.57	-	-
Conyza	0.41	-	E**; K**; T**
Cirsium	-	0.29	E**
Daucus	0.19	-	-
Diplotaxis	-	0.13	-
Hypochaeris	-	0.13	-
Lamium	-	0.13	-

*VP = The value for Phytoseiidae mites is based on the occurrence frequency of phytoseiid species (E = *Euseius stipulatus*; K = *Kampimodromus aberrans*; T = *Typhlodromus* (*Typhlodromus*) *pyri*) associated with a genus weed (* < 0.5 %; ** = 0.50-1 %; *** = 1-2 %; **** = 2-3 %) (Tixier 2018).

Table 3

Biodiversity values of cover crop vegetation

	Spontaneous cover 2016	Spontaneous cover 2017	Flower-driven cover
H′	2.36	2.28	1.68
^0D	20	15	6
^1D	10.62	9.77	5.37
^2D	7.14	3.03	5.00

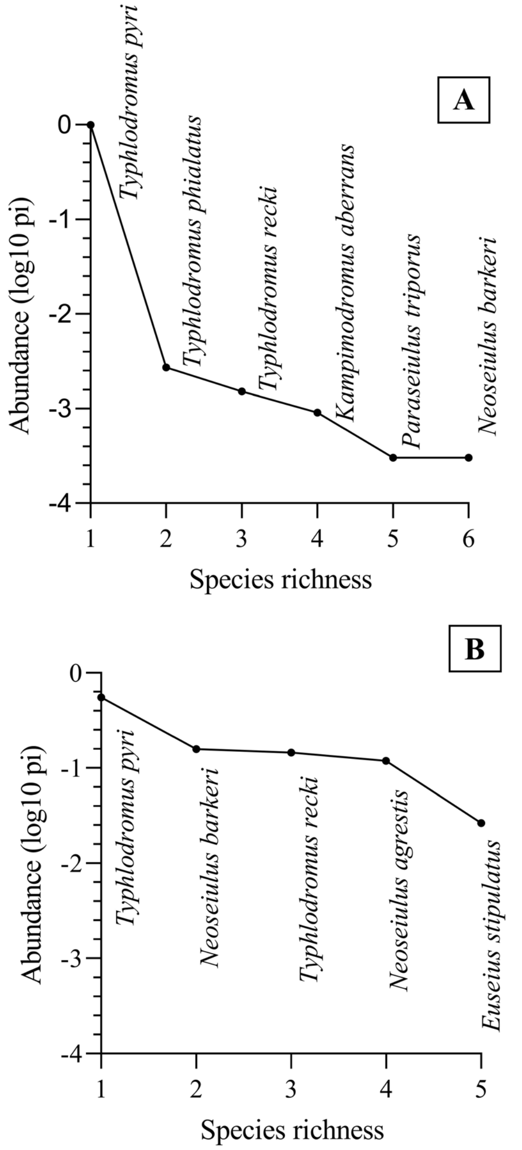

Fig. 2: Rank-abundance curves of phytoseiid mites collected on **A**. grapevine canopy and **B**. ground cover vegetation.

T. recki and *T. phialatus* Athias-Henriot were observed in all three treatments. *Kampimodromus aberrans* was found in Tillage and Spontaneous Cover treatments. Additionally, *N. barkeri* and *Paraseiulus triporus* (Chant & Yoshida Shaul) were only recorded in the Spontaneous Cover treatment. In the ground-cover vegetation, *T. pyri* and *N. barkeri* were found in both cover-crop treatments, whereas *T. recki* and *Euseius stipulatus* (Athias-Henriot) were only observed in the Spontaneous Cover treatment, and *N. agrestis* in the Flower-driven Cover treatment.

Abundance and population dynamics of phytoseiid mites: Overall, 11,627 phytoseiids were collected during the two years of study; 94 % and 6 % were captured in the grapevine canopy and on the cover-crop vegetation, respectively. The abundance of mites on the grapevine canopy was significantly different between 2016 and 2017 (818.89 ± 58.63 and 400.89 ± 42.20, respectively; $F = 5.79$, $df = 1$, $P < 0.001$). However, these differences between years were not significant on the cover-crop vegetation (61.00 ± 12.20 and 47.00 ± 27.24; $F = 0.47$, $df = 1$, $P > 0.05$). Similar trends in the population dynamics of phytoseiid

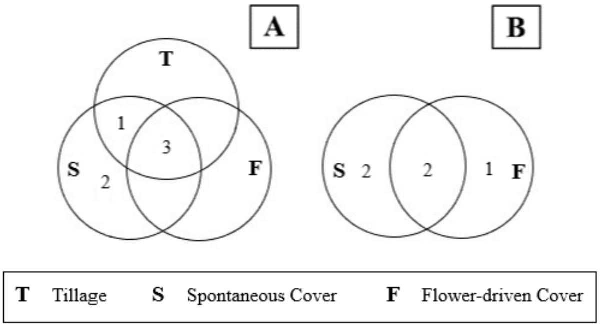

Fig. 3: Venn diagram "richness" of phytoseiid mites collected on **A**. grapevine canopy and **B**. ground cover vegetation.

mites were observed between years both on the grapevine canopy and cover-crop vegetation, with higher abundance at the beginning of the vegetative cycle of the grapevine (Figs. 5 and 6). The greatest abundance of phytoseiid mites was observed at the end of May 2016, coinciding with phenological stage 15-G (flowers closely pressed together). This was nearly three times higher than the abundance of phytoseiid mites collected at the same phenological stage in 2017. Furthermore, the Flower-driven Cover treatment showed the highest total abundance of phytoseiid mites in the grapevine canopy, being almost 1.30 times higher than in the Tillage and Spontaneous Cover treatments (Fig. 5). This elevation in the Flower-driven Cover was statistically significant at certain summer sampling dates in both years: 7 July 2016 ($F = 9.08$; $df = 2$, $P < 0.05$), 1 September 2016 ($F = 10.04$, $df = 2$, $P < 0.05$), 29 September 2016 ($F = 35.55$, $df = 2$, $P < 0.001$) and 10 Aug 2017 ($F = 15.95$, $df = 2$, $P < 0.05$). In contrast, the presence of spontaneous vegetation significantly affected total abundance of phytoseiids within the ground-cover vegetation in 2016 ($F = 3.30$, $df = 2$, $P < 0.05$), being nearly twice that in the Flower-driven Cover treatment (Fig. 6).

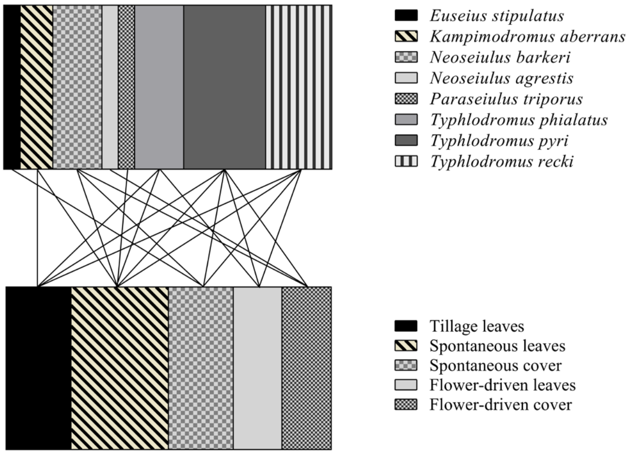

Fig. 4: Phytoseiid mite-treatment interaction networks. The top level shows the phytoseiid species collected and the lower level shows the treatments and the sampling zones. The connecting lines represent interactions between the two levels.

Discussion

Our initial hypothesis that ground-cover vegetation positively affects the abundance and richness of predatory mites in vineyards was supported. Thus, plant community composition, phenology and pollen production during flowering seem to be determinant factors that preserve phytoseiid mites in vineyards.

The importance of vegetation features and diversity in plant communities for the occurrence of natural enemies is well-known (Aguilar-Fenollosa *et al.* 2011, Landis *et al.* 2000). Parameters such as richness, % coverage and other features of vegetation cover could have an important impact on abundance of phytoseiids (Miñarro and Kreiter 2012). We found a positive correlation between vegetal biodiversity and phytoseiid species richness, as reported by

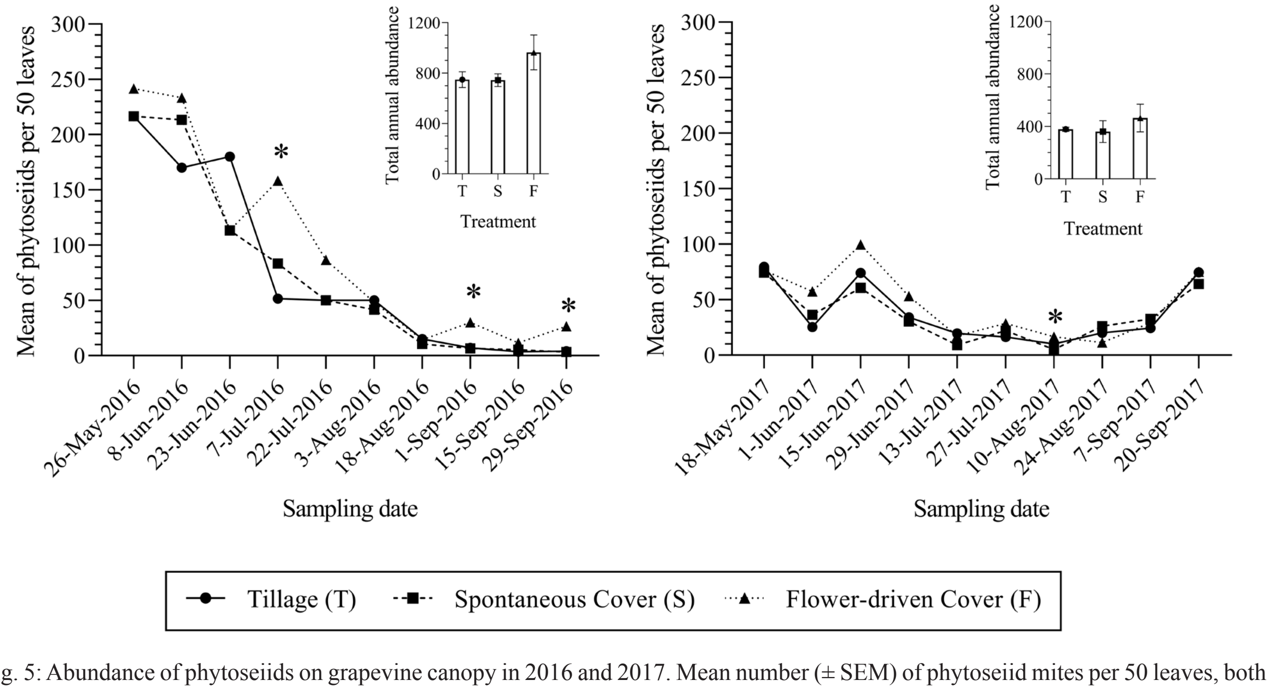

Fig. 5: Abundance of phytoseiids on grapevine canopy in 2016 and 2017. Mean number (± SEM) of phytoseiid mites per 50 leaves, both per sampling and year. Asterisk indicates significant differences between treatments, by ANOVA ($P < 0.05$) and Tukey test.

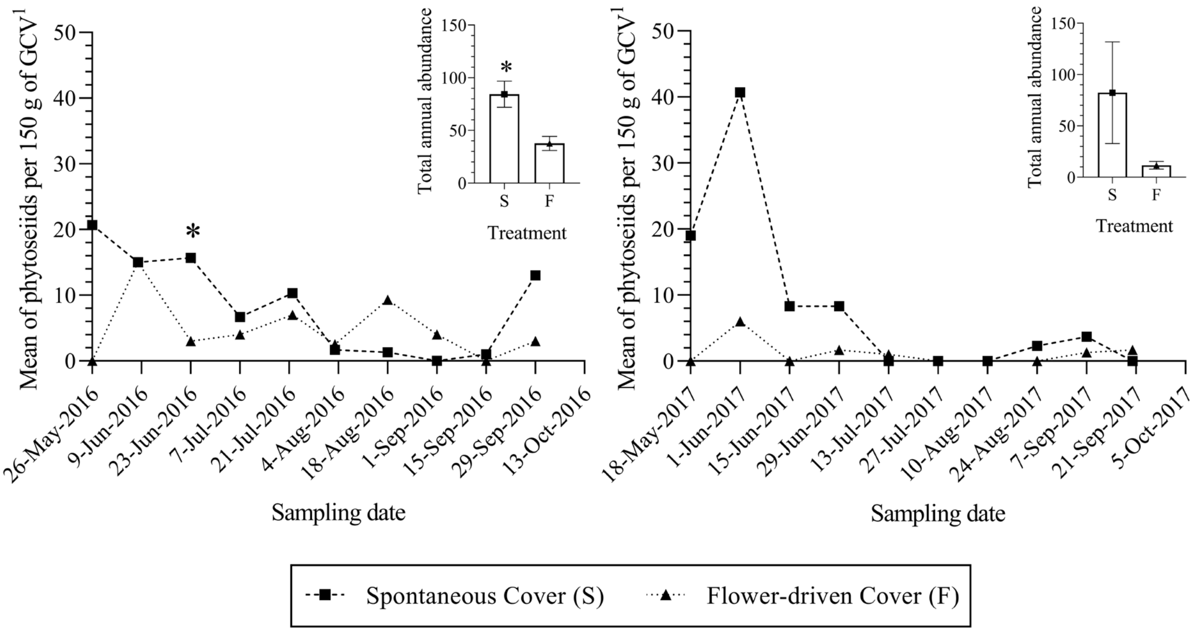

Fig. 6: Abundance of phytoseiids on ground cover vegetation in 2016 and 2017. Mean number (± SEM) of phytoseiid mites per 150 g of ground cover vegetation, both per sampling and year. ¹ GCV = Ground cover vegetation. Asterisk indicates significant differences between treatments, by ANOVA ($P < 0.05$) and Tukey test.

other authors (Barbar *et al.* 2005, Letourneau *et al.* 2011, Ratnadass *et al.* 2012). Therefore, it is essential to take this into account when deciding the cover-crop composition. For example, plant features might have a greater effect than prey availability on phytoseiid abundance (Duso *et al.* 2004, Karban *et al.* 1995).

The predatory mite species assemblage found on the grapevine canopy was consistent with data reported by Pérez Moreno (1997) in La Rioja vineyards. Some of the phytoseiid species observed are widespread on vines in the Mediterranean area and all have already been reported in Spanish vineyards (Miñarro and Kreiter 2012, Burgio *et al.* 2016). *T. pyri* was the dominant species, consistent with its preference for pubescent leaves and its high tolerance to pesticides, especially fungicides (Auger *et al.* 2005, Bonafos *et al.* 2007). In addition, its body is smaller than that of other phytoseiids, enabling it to easily move among the leaf hairs and maintain a high density (Duso 1992). Consequently, *T. pyri* is considered a predator of major importance in viticulture (Duso *et al.* 2012).

The captured species belonged to three previously categorized lifestyle types: type I, specialized predators of tydeids (e.g. *Paraseiulus* sp.); type III, generalist predators (e.g. *Kampimodromus* sp., *Neoseiulus* sp. and *Typhlodromus* sp.); and type IV, pollen-feeding generalist predators (e.g. *Euseius* sp.) (McMurtry *et al.* 2013). Type III species captured included: *T. pyri*, *T. phialatus*, *T. recki* and *K. aberrans* living on pubescent leaves (subtype IIIa); and *N. barkeri* that periodically move up from soil habitats onto low-growing plants (subtype IIIe) (McMurtry *et al.* 2013). The phytoseiids *E. stipulatus* and *N. agrestis* were found only in the cover vegetation (*E. stipulatus* only was recorded in the Spontaneous Cover vegetation). This distribution reflects the link between plant morphology and predator traits; herbaceous plants such as weeds would be favourable to *E. stipulatus* (Tixier 2018). Conversely, *T. phialatus, K. aberrans* and *P. triporus* were only observed on the vine canopy, consistent with their preference for woody or arboreal plants (Tixier 2018). However, *T. pyri* was found on both the grapevine canopy and ground-cover vegetation, perhaps reflecting its high predatory efficiency and mobility (Tixier *et al.* 2000, Duso *et al.* 2012).

Cover-crop pollen deposited on leaves can influence phytoseiid mite abundance by supplementing the nutritional requirements of these predators (Landis *et al.* 2000, Burgio *et al.* 2016). Some species even show better development on pollen than on prey (McMurtry *et al.* 2013). In addition, the 'Tempranillo' grape variety has pubescent leaves, which provide excellent pollen traps (Kreiter *et al.* 2002). We observed that *T. pyri*, increased its population when pollen was abundant on vine leaves, which is in agreement with Duso *et al.* (2004, 2012). Other studies have demonstrated that vineyards managed with cover crops show a natural increase in phytoseiid abundance (Burgio *et al.* 2016, Tixier *et al.* 1998). This might be explained by migration of predatory mites onto the grape leaves from the cover vegetation and by a favourable microclimate, such as locally higher humidity or lower temperature (Landis *et al.* 2000, Irvin *et al.* 2016).

With respect to population dynamics, phytoseiid mites were found on the crop throughout the growing period, although their abundance differed between years, being lower in 2017. This may have been caused by weather conditions, particularly the higher maximum temperatures and the lower relative humidity during May and July 2017. That we did not observe significant differences between treatments at grapevine canopy level until mid-summer may reflect pollen availability on leaves, which would be higher in spring and early summer than in late summer. Pollen occurs naturally in vineyards during phenological stage 23-I (flowering time) and could be provided by ground-cover vegetation, depending on its species composition. In this respect, Spontaneous Cover vegetation was mainly characterized by plants with relatively short and early flowering periods (Storkey 2006). However, the Flower-driven Cover produced pollen throughout the whole grapevine growing season supporting predatory mites, particularly at the end of the grape flowering period. Likewise, the reduction in the number of phytoseiid mites recorded in late June in the Spontaneous Cover treatment might have been caused by grass mowing, which could have reduced pollen abundance in the canopy (Mailloux *et al.* 2010). Conversely, in accordance with Vogelweith and Thiéry (2017), the higher numbers of phytoseiids observed on the inter-row vegetation in the Spontaneous Cover treatment than in the Flower-driven Cover treatment might be explained by a switch from the grapevine canopy to vegetation in the rows when food was less available.

To conclude, vegetation cover, particularly in the Flower-driven Cover treatment, increased the abundance of predatory mites in comparison with Tillage and Spontaneous Cover treatments. Flowering plants could provide considerable quantities of pollen and may represent a useful strategy to enhance the survival of phytoseiid mites in vineyards, thereby achieving better agroecosystem management and promoting agroecosystem services such as CBC.

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